Effects of inulin fibre Supplementation on Serum Glucose and Lipid Concentration in Patients with Type 2 Diabetes

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Abstract

Individuals who develop type 2 diabetes increase their chances of developing other health concerns such as cardiovascular disease. Soluble fibre has been shown to have positive effects on serum lipid and glucose levels. Inulin is a type of soluble fibre whose effects on serum lipid and glucose levels in individuals with type 2 diabetes are inconclusive due to the few studies that have been conducted. This study examined the effects of daily intake of 10 g of inulin-based fibre. This study included 36 individuals diagnosed with type 2 diabetes. Using a randomized, double-blind design patients consumed 10 g of either an inulin fibre supplement or xylitol as a placebo for 12-weeks. Compliance, expressed as the proportion of supplements not returned, was near 100% for both treatments. Inulin supplementation did not significantly affect fasting concentrations of serum total cholesterol, HDL cholesterol, LDL cholesterol, serum triglycerides, serum glucose, or hemoglobin A1c values. These results indicate that daily consumption of 10 g of inulin for 12 weeks does not affect serum lipid and glucose levels in patients with type 2 diabetes.The significant finding(s) of the Study: Short term supplementation of inulin is not effective in changing serum glucose and lipid profiles among those with type 2 diabetes.The study adds: Inulin supplementation on a short term may not be needed or effective in changing serum glucose and lipid profiles among individuals with well managed diabetes.

Keywords: *diabetes, inulin, fibre, serum glucose, serum cholesterol*

Introduction

Approximately 1.9 million individuals have been diagnosed with diabetes in Canada.[1] Diabetes is one of the fastest growing chronic diseases with high levels of mortality and morbidity associated with the condition.[2,3] Approximately 90% of individuals with diabetes have type 2 diabetes with increasing incidences reported after the age of 40.[1,2] The incidence of diabetes in individuals under the age of 40 occurs at a rate of 1.2 per 1000 persons, whereas the incidence in individuals over the age of 40 occurs at a rate of 11.6 per 1000 persons.[1]

For the clinical diagnosis of diabetes, a fasting plasma glucose test is used. Normal fasting serum glucose is defined as less than 5.6 mmol/L of blood plasma, whereas the serum glucose of diabetic patients is greater than 7.0 mmol/L of blood plasma.[4] Also, individuals with diabetes often experience atherosclerotic changes which manifests as coronary artery disease, peripheral artery disease and cerebrovascular disease.[5] These lipid abnormalities, raising of low-density lipoprotein levels and decreased levels of high-density lipoproteins, are independent risk factors for coronary events in individuals who are newly diagnosed with diabetes.[6] Therefore, managing the serum lipid and glucose concentrations in individuals who have been diagnosed with diabetes is important.

In the health promotion arena, it is well known that overall diet has an important role to play in the management of diabetes and cardiovascular diseases.[7,8] Current research has indicated that soluble fibre in particular may have a lowering effect on serum glucose by reducing the post-prandial glucose response.[8] An increase in daily dietary fibre intake is associated with the reduced incidence of chronic diseases such as diabetes.[9] However, most Canadians consume far less than the recommended daily dietary fibre intake for Canadians is 25 to 38 grams per day.[10,11] Additional fibre options may be beneficial in increasing daily dietary fibre intake. Inulin is a type of soluble fibre from a family known as fructans and naturally found in thousands of plants including: onions, bananas, garlic, Jerusalem artichoke, asparagus root, and chicory root.[12] As a type of dietary fibre, inulin is fermented in the digestive tract13 resulting in the formation of short chain fatty acids (SCFA) which have the ability to lower serum glucose and lipid levels in the body.[14,15] While the results of the impact of inulin on glucose and lipid levels have been conclusive in animals[16], there has been a paucity of research examining this issue in humans.

To date, only 15 studies have examined the impact of inulin-type fructans on serum glucose and lipid levels, and only three of these studies involved participants who had been diagnosed with type 2 diabetes. Among the 15 human

Received on: 9 September, 2012
Accepted on: 18 November, 2012

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studies, seven showed no statistically significant differences concerning serum glucose and lipid levels, while eight showed statistically significant differences. The number of participants in these studies ranged from 7 to 66 individuals with different health status ranging from healthy (n = 7), high cholesterol (n = 4), nonalcoholic steatohepatitis (n = 1) and diagnosis of diabetes (n = 3). The fructan dosage for these studies ranged from eight to 20 grams per day. Only four of these studies had intervention duration of over eight weeks (see Table 1). There is a clear need for studies with longer duration of intervention and with optimal dosage of inulin supplementation especially among those with chronic diseases such as type 2 diabetes.

Of the three studies that involved individuals diagnosed with type 2 diabetes, serum glucose and lipid concentrations decreased in only one study with eight grams of inulin consumed per day[17] and no statistically significant change was observed in two studies with higher dose of inulin such as more than 15 grams.[14,18] In addition, larger doses (16-20 grams per day) have been shown to promote a feeling of satiety after a meal[19] perhaps contributing to poor compliance in the intervention. Also, the duration of the interventions has been primarily less than eight weeks in most studies.[16] Only four of the studies in the review were at least eight weeks in length, with a range of eight weeks to 24 weeks.[20-23] Of these four studies, only one had any impact on serum glucose levels with a decrease in insulin concentrations at midpoint of study.[23] Not one of these previously mentioned studies utilized a population which had been diagnosed with diabetes. The literature clearly suggests a lack of research on the long-term impact of inulin, especially concerning individuals diagnosed with type 2 diabetes. Thus, the purpose of the present study was to examine the effect of a 12-week supplementation of inulin on serum glucose and lipid levels in adults over 40 years of age with a diagnosis of type 2 diabetes.

Methods

Sample and research design

Thirty six individuals over 40 years of age and who had been diagnosed with type 2 diabetes within the past 10 years were recruited for this study. Sample size calculations were based on an alpha level of 0.05, a desired statistical power of 0.80, and a moderate effect size of 0.40.[24] Exclusion criteria included: adults diagnosed with dementia, older adults in long-term care facilities, unstable medical conditions, and palliative/terminal conditions. A 12-week, double-blinded, randomized control trial design was used in this study.

Participants in the study were randomly assigned to the experimental and control study groups using the Statistical Package for the Social Sciences (SPSS version 15) random sample of cases protocol. Both the primary researcher and participants of the study were not aware of their group membership during the intervention period ensuring the double-blinded feature of the study design. The study received ethics approval from the university and regional health authority ethics review boards prior to the start.

Intervention

Participants in the experimental group received a fibre supplement composed of inulin, while the participants in the control group received a placebo composed of xylitol. A xylitol based natural sweetener was used as the placebo as it had similar physical properties to the fibre supplement (i.e. solubility in beverages and food). The sweetener had a low glycemic index that would not adversely affect the health status of the participants in this study. Both the fibre supplement and the placebo were given to the participants in powder form and in similar, unmarked, individualized, daily use sachets of 10 grams each.

The daily dose of the placebo and fibre supplement was set at 10 grams per day. Examination of the literature indicated that consumption of very high doses of xylitol (≥ 35 grams per day) has been shown to increase nausea, bloating, borborygmi, colic, watery feces, and total bowel movement frequency.[25] Also, based on the existing literature, the daily consumption of the inulin fibre supplement was also set at 10 grams per day. This level was determined to be sufficient to produce statistically significant results in serum lipid and glucose levels.[17,26,27] In addition, higher doses (16-20 grams) have been shown to cause satiety and have not been shown to have statistically significant effects.[14,18,19] Participants were asked to consume one sachet per day, preferably in the morning at breakfast with a beverage (e.g. tea/coffee/orange juice/water) or their regular breakfast food.

In order to minimize dropout rates, participants in both the experimental and control groups received a phone call every four weeks. This phone call was intended to act as a reminder to the participants to engage in their respective activities, act as encouragement to the participants, and answer any questions or concerns that might have arisen throughout the course of the study period. Participants were also given a calendar to mark down each time they consumed their respective supplements. Participants were encouraged to maintain their regular daily eating and exercise habits since lifestyle habits were not being controlled in this intervention study.

Measures

All measures were completed at baseline and at 12-week follow-up. Testing for all measures occurred in the morning hours (8 – 10 am) in order to decrease time of day variability in each of the participants' results.

Background Questionnaire

A background questionnaire was used to obtain demographic information and health status for each participant at baseline. Questions ranged from demographic information such as, ethnicity, age and income.

Anthropometric Measurements

Body mass, height, hip circumference, waist circumference, and body mass index were measured at baseline and at 12-week follow-up. Standard procedures were adopted to measure these anthropometric parameters.[28]

Biochemical Testing

Biochemical variables included serum glucose, hemoglobin

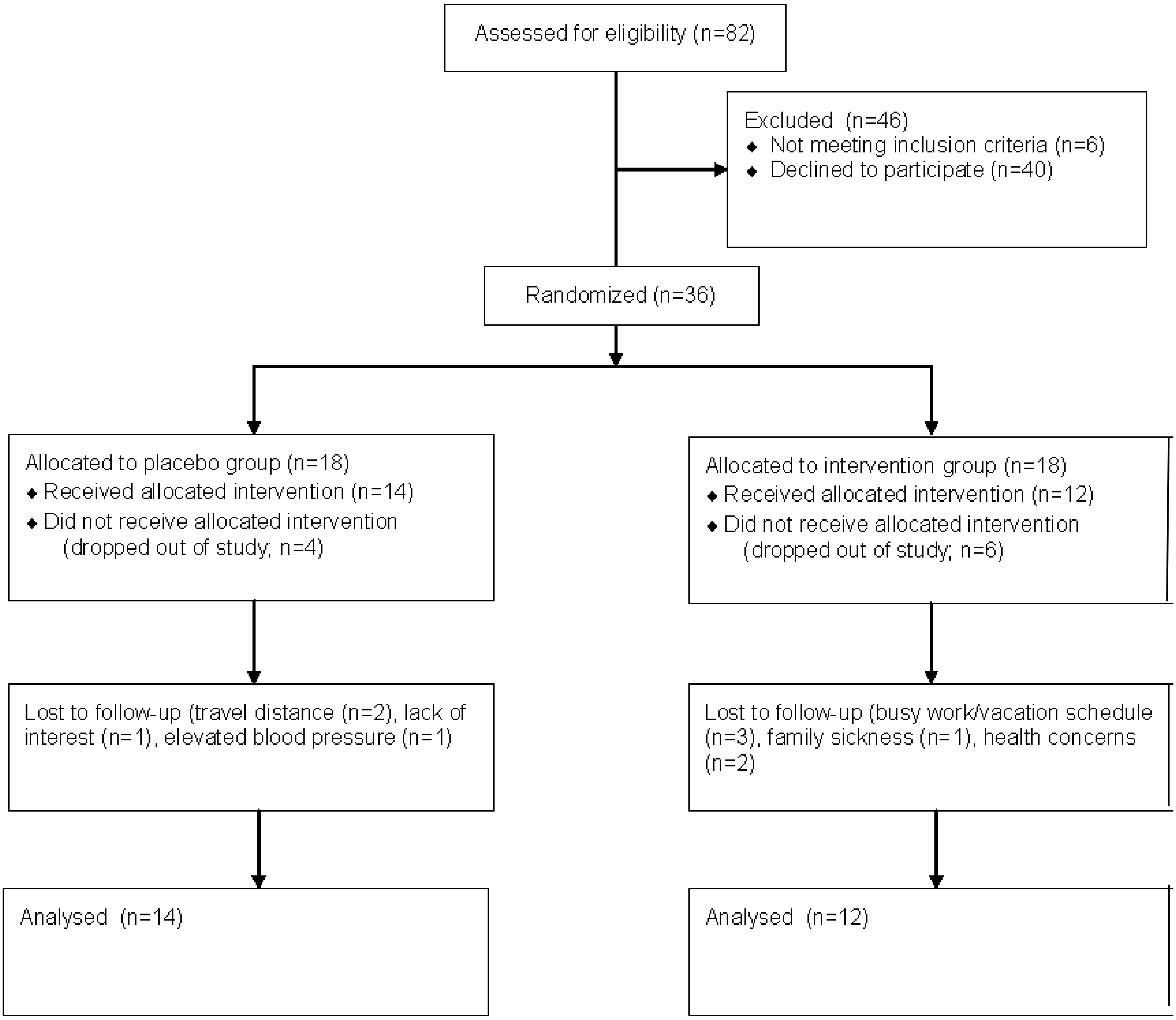

Figure 1: Flow diagram of the study

A1c (HbA1c), LDL, HDL, TC, and TG levels. The TC:HDL ratio was calculated based on the above measurements for TC and HDL. The fasting blood testing for the lipid and plasma glucose levels of each participant occurred on a predetermined day. As per standard protocol, the participants were reminded to fast 12 to 14 hours before testing to ensure the body was in a post-absorptive state.[29] Blood was drawn by a laboratory technician by venipuncture according to standard protocol at the investigators' university.

Dietary Intake

The 3-day dietary records were completed, and returned, by study participants at baseline and 12-week follow-up. These dietary records were used to collect data on average fibre intake of the study group participants. For the 3-day dietary record method, the participants were asked to keep a dietary record for two week days and one weekend day. In order to ensure accuracy of the dietary record, quality assurance strategies were put into place.[30] Specifically, the participants were provided detailed verbal and written instructions on how to keep a good food record. An example of a completed food record was provided for each participant to use as a guide. Participants were required to return the dietary records to the primary researcher. The records were then reviewed for completion by a trained research assistant. The nutrient intake of each participant was plotted against their nutritional requirement using the CANDAT – Research Oriented Nutrient Calculation System (Godin London Incorporated, nd).

Exit Questionnaire

At follow-up, a second questionnaire was administered. This questionnaire consisted of four questions to record whether any side effects had occurred during the duration of the study resulting from the ingestion of the supplement or the placebo. The follow-up questionnaire also was used to determine whether the participants were able to identify their group membership.

Compliance

In order to monitor compliance, participants recorded whether they consumed their sachet each day on the monthly calendar that was provided at baseline. Additionally, participants were asked to return any empty sachets which contained the fibre supplement or placebo. Compliance was assessed by examining the monthly calendars and the returned sample sachets which participants brought back at follow-up. To encourage compliance, the supplement and placebo were provided in individualized sachets and in small quantities (10 grams) to avoid any side effects associated with the consumption of large amounts of each product. Participants also received a monthly telephone call to encourage compliance.

Data analysis

Completed assessments were entered and analyzed in SPSS version 15. Independent t-test calculations were used to assess if any differences existed between individuals in the experimental and control groups at baseline. Subsequently, mixed-model ANOVA's with one repeated factor was used to compare between groups, and over time regarding the biochemical profile (serum lipid and glucose levels). The use of the fibre supplement or placebo acted as the first factor (between-participants) and time (pretest and posttest) was a second (repeated) factor. Statistical significance was set at $p \leq 0.05$ for all statistical procedures.

Results

Baseline data were completed by 18 participants in the experimental group and 18 participants in the control group. The average age of the 36 participants was 64.64 years (*SD* = ± 9.27). A total of ten participants were lost due to attrition. Follow-up data and assessments were completed for 12 members of the experimental group and 14 members of the control group. Table 1 compares the baseline demographic data of the study group participants. The average age of the participants in both groups was 65 years of age with an average duration of diabetes of six years. Groups were almost equally split along gender lines with males comprising 58% and 50% of the experimental and control groups, respectively. The participants' average BMI was greater than 30 and fell into the World Health Organization's Obese Class I category.[31] Analysis of the 3-day food records indicated that there were no statistically significant differences in average daily intakes of energy or dietary fibre between the two groups at baseline. Daily dietary fibre consumption was approximately 21 grams per day at both baseline and follow-up, and these values were below standards put forth by Health Canada.

A mixed-model analysis of variance (ANOVA) was conducted to assess the impact of the two different interventions (receiving inulin-type fibre versus receiving a placebo on study group participants over time (baseline to follow-up). Baseline and follow-up scores for serum glucose and serum lipid responses are presented in Table 2 for those participants who completed the study. The actual intervention that each study group underwent (consumption of fibre vs. consumption of xylitol sweetener) produced no statistically significant effect for any of the assessed dependent variables. Specifically, inulin supplementation did not significantly affect fasting concentrations of serum total cholesterol, HDL cholesterol, LDL cholesterol, serum triglycerides, serum glucose, or hemoglobin A1c values.

Table 1: Baseline characteristics of participants

	Experimental group (*n* = 12)		Control group (*n* = 14)	
	M	*SD*	*M*	*SD*
Age (years)	64.0	5.8	66.0	11.2
Duration of diabetes (years)	6.0	3.7	6.0	4.4
Mass (kg)	85.6	17.9	83.0	14.1
BMI (kg/m^2)	31.0	4.5	29.7	4.3
Waist Circ. (cm)	103.3	14.1	102.3	10.9
Hip Circ. (cm)	111.4	10.7	107.4	9.0
Waist:Hip	0.9	0.1	0.1	0.1
Fibre intake	22.6	10.4	20.9	7.3

Compliance levels were also high for each intervention group. All participants consumed either the inulin-based fibre supplement, or placebo, over 80% of the time during the 12-week intervention period, or the equivalent of 84 days. Twenty-three participants consumed their samples at least 95% of the time and the remaining three participants took the samples at least 90%, 85% and 80%, respectively. The total number of days that participants consumed their respective samples ranged from 69 to 84 days over the 12-week intervention period (*M* = 82.12; *SD* ± 3.77).

Discussion

The present study examined the effects of a 12-week supplementation of inulin-based fibre on serum glucose and lipid levels in individuals over 40 years of age with a diagnosis of type 2 diabetes. Based on a previous literature search, this study was the first to evaluate the effects of long-term consumption (12 weeks) of inulin-based fibre on HbA1c, serum glucose and serum lipid concentrations in this particular clinical population. The study showed that consumption of 10 g/d of a powered inulin-based fibre supplement did not significantly affect HbA1c, serum glucose, or lipid concentrations in individuals diagnosed with type 2 diabetes.

Previous research has shown that inulin-type fructans may have lowering effects on serum lipid levels in humans, particularly those with hypercholesterolemia.[16] However, the present study involved individuals with well managed diabetes as was evident from the baseline glucose and lipid profile and the results showed no statistically significant

Table 2: Biochemical scores of the two groups of participants

	Experimental group (n = 12)				Control group (n = 14)			
	Baseline		Follow-up		Baseline		Follow-up	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
TC (mmol/L)	4.5	0.9	4.2	1.0	4.6	0.8	4.5	1.2
HDL (mmol/L)	1.2	0.3	1.2	0.3	1.2	0.3	1.2	0.3
LDL (mmol/L)	2.6	0.9	2.4	0.8	2.7	0.7	2.5	0.8
TG (mmol/L)	1.5	0.5	1.5	0.6	1.6	1.0	1.8	1.2
TC:HDL	3.9	1.2	3.7	1.0	4.1	1.4	4.2	1.6
Glucose (mmol/L)	7.5	1.3	7.6	2.6	7.6	1.6	7.4	1.4
HbA1c (%)	7.0	1.3	7.3	1.5	7.2	1.7	7.1	1.2

impact from the inulin consumption for 12 weeks. This raises the possibility of the effectiveness of inulin in individuals with elevated levels of glucose and lipid profile and not among those with normal levels, therapeutic function of inulin, and the timing of the supplementation in relation to the diagnosis of diabetes. These propositions should be examined comparing the effect of similar dose in individuals with healthy and elevated levels of lipid and glucose and various time points since diagnosis of diabetes. Previous research, using animals diagnosed with diabetes, has resulted in conclusive results which highlight the health benefits of consuming inulin.[16]

The findings of the present study are different from other studies examining this issue using animal models, primarily those conducted with rats that have consistently shown the positive effects of inulin.[32-34] The lack of statistically significant differences in the present and other human studies may be related to doses of supplements used in animal versus human studies. In all of the previously mentioned rat studies, each animal was fed a diet consisting of 10% of fructans, which provided a mean food intake of 23 grams/day, resulting in an average body mass of 300 grams at the end of the study. For rats, the intake of fructans per kilogram of metabolic weight (body weight 0.75) was approximately 5.7g/kg. In the present study, the average mass of the participants in the experimental group at baseline and follow-up was 85.6kg and 82.3 kg respectively. Thus, the average intake was 0.4 g/kg of metabolic weight. Therefore, based on mean metabolic weight, the rats in the former studies were consuming over 14 times the amount of fructans than participants in the present study. In plain terms, the rats in these previous studies were consuming over 140 grams/day of fructans; this is not a viable intake amount for humans. In human studies, the dose has ranged from eight to 20 grams per day. This also raises important questions about the optimal dose of inulin in relation to possible dose-response and optimal dosage which have not been studied in humans.

Also, in the present study, xylitol was used as a placebo as the alternates, glucose, sucrose, and maltodextrin, were not appropriate for individuals with diabetes due to their high glycemic index values.[35] Xylitol is a type of sugar alcohol known as a polyol and is considered a monosaccharide.[36,37] It is used as a sugar substitute due to its sweetening power, low cariogenicity and reduced energy content.[38] The low energy content occurs because sugar alcohols are only partially absorbed in the digestive tract.[38] The slow conversion of xylitol to glucose ensures that any rise in serum glucose or insulin concentrations, after a meal, is modest.[39] The partial absorption in the digestive tract and the slow conversion process to glucose, contribute to the low glycemic index value that xylitol possesses.[40] The majority of the research regarding xylitol pertains to its effects in oral care.[41,42]

It is possible that the use of xylitol as a placebo affected the results in this study. This sweetener has a low glycemic index and has been shown to have a lowering effect on serum glucose and insulin levels due to its formation of SCFA.[13,40] The formation of SCFA also occurs upon consumption of soluble fibres, such as inulin.[14] As seen in the present study, statistically non-significant decreases occurred in almost all of the variables in the control group when values measured at baseline were compared to those measured at follow-up. Thus, the use of xylitol as the placebo is an aspect in this study that could have played a role in the findings of the present study. However, among individuals with diabetes, there are no suitable placebo options and raises methodological considerations in conducting a controlled trial.

The statistically non-significant results from this study do not necessarily mean that inulin-type fructans have no health benefits across populations. The prebiotic, bifidogenic nature of inulin-type fructans has many non-glucose health related benefits such as the reduction of ammonia in the blood[12] and can greatly reduce constipation.[43] Lipid levels are of importance since high serum lipid levels are often a complication occurring in individuals with diabetes.[44] In addition, research has shown diets rich in dietary fibre improve glycemic control and aid in the management of diabetes.[45-47] Research has also consistently shown that individuals do not consume the recommended level of fibre.[10,11] Providing additional options for obtaining the recommended fibre level may be a benefit at the population level.

Conclusion

In conclusion, 12 weeks of daily ingestion of 10 grams of inulin fibre had no statistically significant effect on serum glucose and lipid levels in individuals who had well managed type 2 diabetes. Also, as discussed earlier, a number of questions have been raised related to target group (healthy versus those with uncontrolled blood lipid and sugar levels), dose-response issues, and choice of appropriate placebo in studies involving clinical populations. It is hoped the present study will serve as a catalyst for future research in this area.

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